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FAA HUMS R&D Plan

FAA HUMS Briefing

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FAA HUMS R&D Plan Program Review

Outline

Objective and deliverables

Task 1 - Technology Assessment

Task 2 - HUMS R&D Requirements

Task 3 - HUMS R&D Roadmap

Discussion

FAA HUMS R&D Plan

*Program objective and deliverables**

Develop a HUMS R&D R&D plan, including a report documenting recommendations for FAA HUMS R&D:

- State of HUMS technologies, certification, and applications
- Future HUMS requirements
- Current R&D activities and programs
- Gap Analysis
- R&D requirements
- 5 & 10 year goals, plans, milestones and ROM costs
- R&D performance metrics and exit criteria

* Shaded deliverables are covered in report, but will not be presented today due to lack of time

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HUMS Technology Assessment

State-of-the-art HUMS functionality

Catch Potentially Catastrophic Failures Before They Occur
Enhance Mission Reliability
Reduce Maintenance Costs

S-61

S-76

S-92

CH-53E

- **Bearing Monitoring**
- **Chip detectors**
- **Drive train vibration**
- **Rotor track & balance**

+

- **HUMS**
- **Adv. Bearing Monitor**
- **Maintenance Data Computer (BIT/IBIT)**
- **CVR/FDR**

1998 → **2003**

Yesterday
Safety

→

Today
Maintenance Credits

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HUMS Technology Assessment

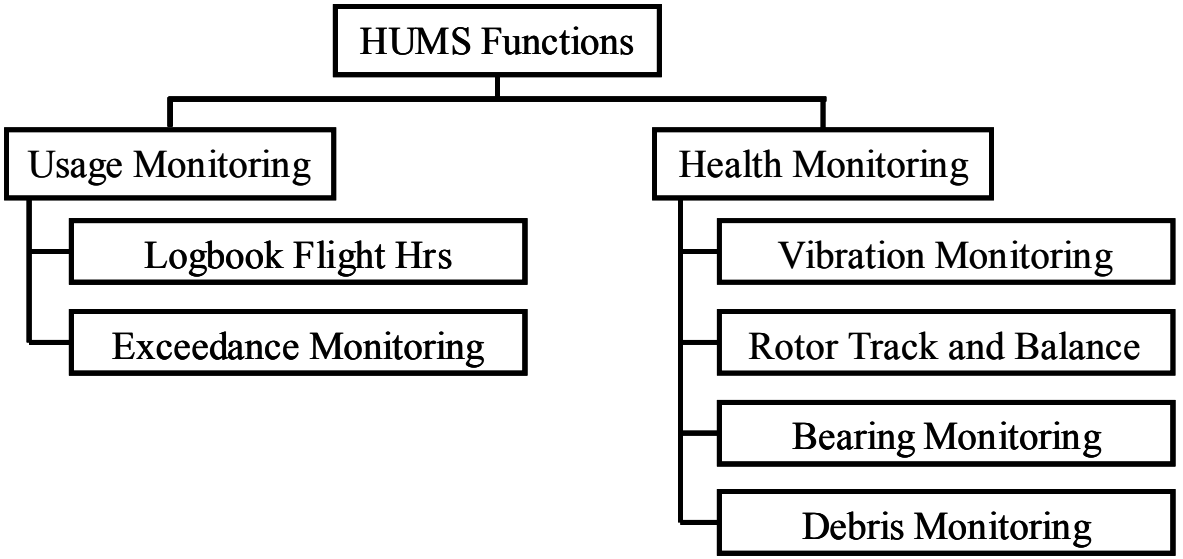
Past State: vibration and debris monitoring for safety

Functions

- Debris monitoring
- Vibration Monitoring
  - Engine Vibration
  - Drive System
    - gear boxes
    - drive shafts
    - hanger bearings
- Rotor Track & Balance
- Continuous data collection
- Auto alarm when thresholds exceeded
- Raw vibration data analysis

S-61

S-76



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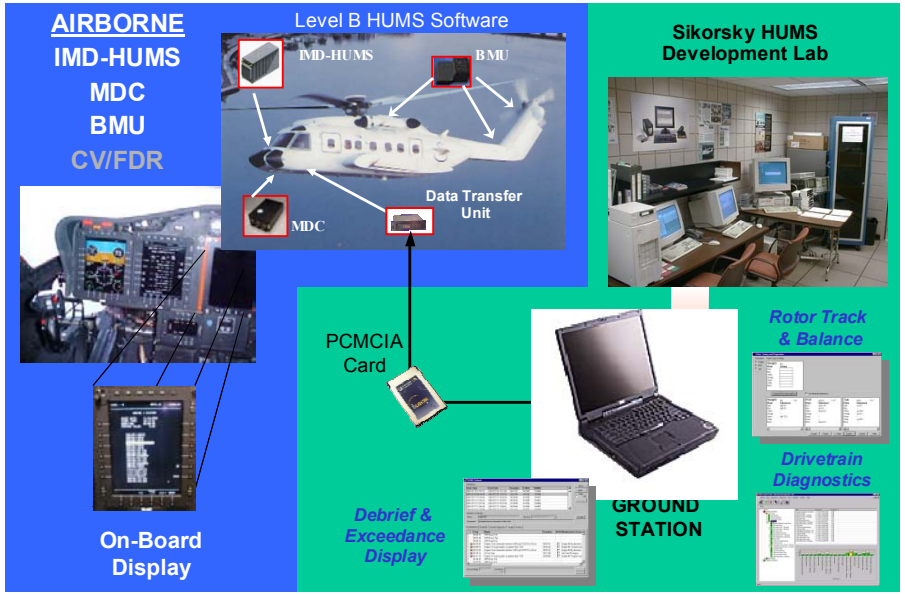
HUMS Technology Assessment

Current State: S-92 HUMS provides integrated aircraft health and credits

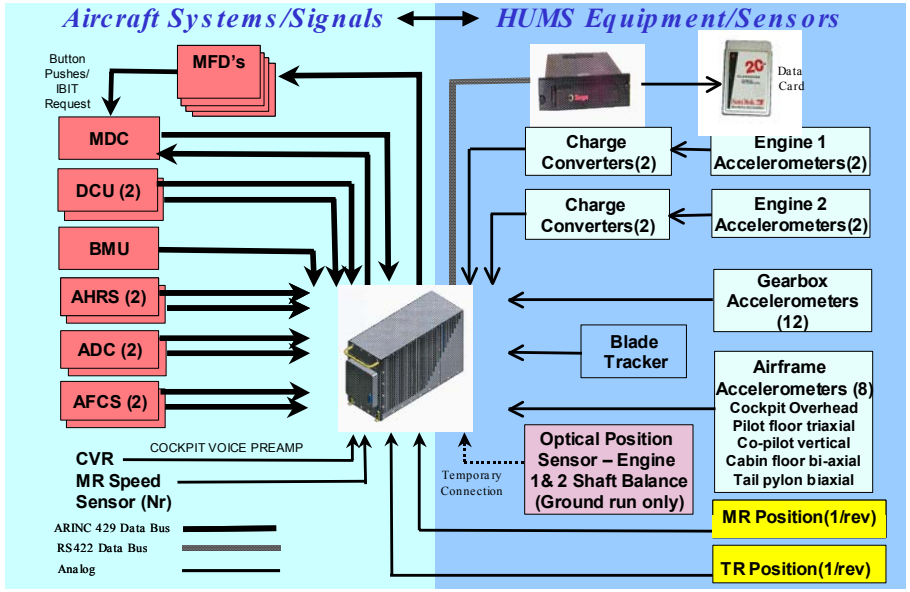
Near-Term Maintenance Credits

Certification Category	Credit	Future
Operational Usage	■	
Rotor Track & Balance	■	
Flight Manual Exceedence Detection	■	
Engine Shaft Monitoring	■	
Engine Shaft Balancing		■
Mechanical Diagnostics		■
Parametric Data Collection		■
Data Trending		■
Regime Recognition		■

System Components



Block Diagram



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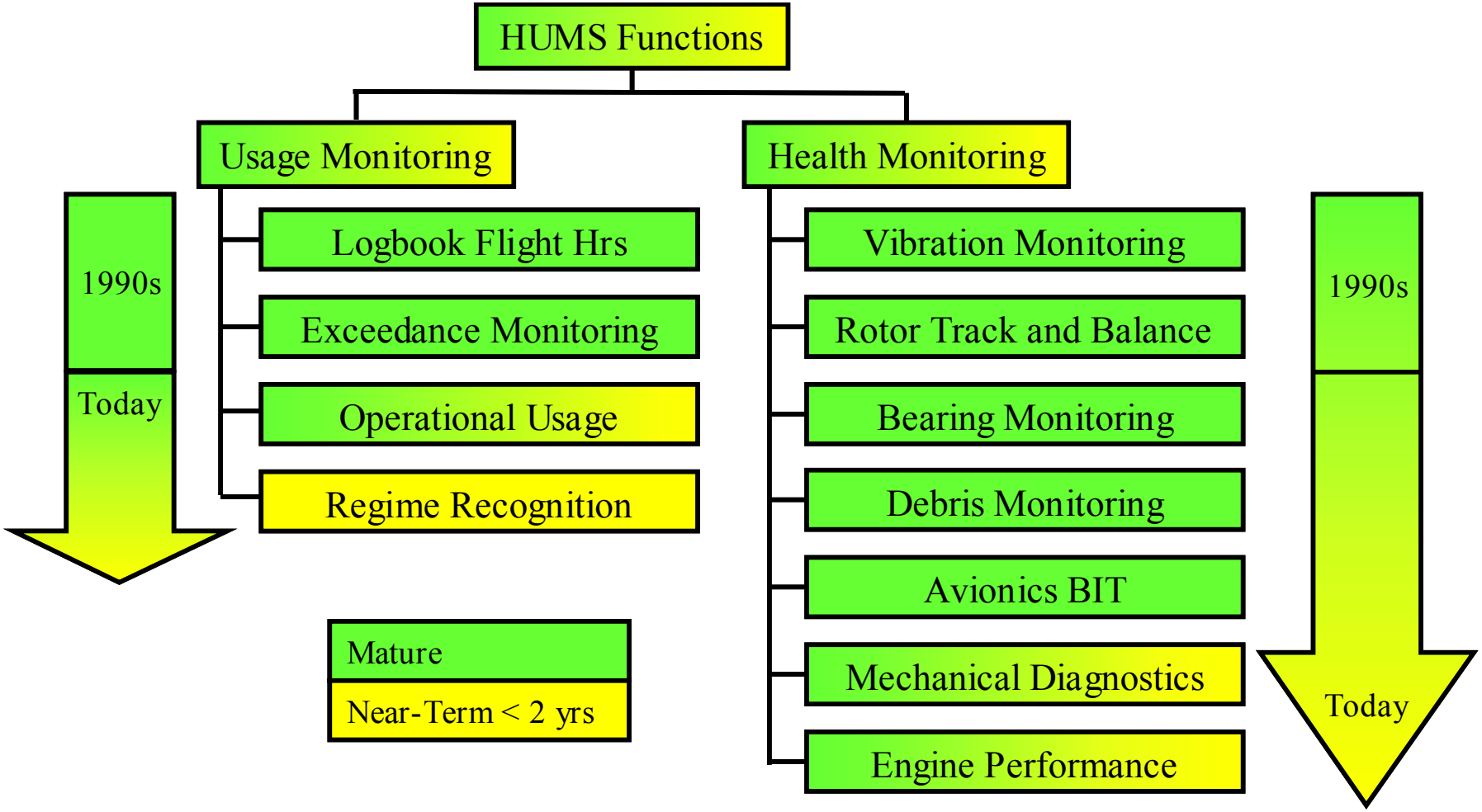
HUMS Technology Assessment

Current State: near-term functionality



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HUMS Technology Assessment

Summary of certification process lessons learned

- Careful end-to-end system definition is crucial.
- A staged incremental certification approach is important.
- Additional cooperation is required between the FAA and industry to develop a viable approach for certifying
  - COTS ground stations
  - HUMS data storage and management systems
  - Software for determining usage-based credits.

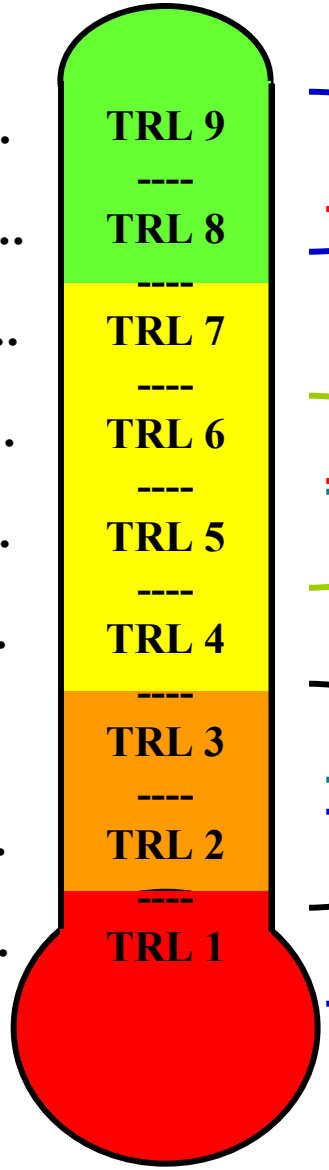
HUMS Technology Assessment

AC-29-2C, Section MG-15 Guidelines – Areas for improvement

- **HUMS Criticality** – The AC should be revised to make clear exactly what HUMS functionality and mitigating actions would produce specified levels of criticality.
  - The link between usage-based maintenance and Level B criticality is implied only
  - No one has been successful in certifying a HUMS usage-based credit system at below Level B.
- **COTS Ground Station certification** – The AC should be modified to define a viable approach for certifying and using a COTS ground station to calculate usage-based credits.
  - The use of HUMS data to calculate usage credits and support maintenance decisions are viewed as providing very similar functionality to well accepted design and maintenance management systems that routinely use COTS hardware and software.
  - It should be possible to use mitigating actions and means for independent verification to make a COTS HUMS ground station viable.
- **HUMS Data Management** – The AC should be updated to provide guidance on how to validate data and ensure data integrity once it leaves the airborne/aircraft system
- **Controlled Introduction to Service** – Section should be clarified with specific guidelines and examples included.
- **In-Flight HUMS Advisories** – Specific guidelines should be developed for in-flight HUMS advisories.

HUMS Technology Assessment

Technology readiness definitions



In Service ……..

Qualification / Certification …….

System Demo ~ Flight Test ……..

Sys/Subsys Demo ~ Relevant Lab Environ …

Component~ Relevant Environ ……..

Component/~ Lab Environ ……..

Analytical /Exp Proof-of-Concept……

Technology Concept ……

Basic Principles ……

- **System Completed**
- **Flt / Mission Qual**
- **System/Subsystem Development**
- **Tech Demo**
- **Tech Development**
- **Research to Prove Feasibility**
- **Basic Research**

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HUMS Technology Assessment

High-Level Technology Breakdown Structure

Cat.	Sub-Category	Tech Assessment					
		Status	TRL	Tech Risk	Cert Risk	Insert Time	FAA Cert?
Hardware	Sensors & Data / Power Transfer	Op	9	Mature to Low	Mature to Low	0	Y
	Airborne System	Op	9	Mature	Mature	0	Y
	Ground Station & Peripherals	Op	9	Mature	Low	< 2	N
Software	Data Management	Op	9	Mature	High	< 2	N
	Diagnostics & Prognostics	Dev	3-7	Low	High	2 - 5	N
	Maintenance Management	D - O	7 - 9	L - M	High	< 2 to 10	N
Algorithms / Methods	Safety Monitoring	Op	9	Mature	Mature	0	Y
	Usage Monitoring	Dev	4 - 7	L - M	High	2 - 5	N
	Diagnostics & Prognostics	Dev	3-7	L - M - H	High	< 2 to 10	N
	Lifing Methods	C - D	2 - 5	Med to High	Med	< 5	N

Tecnology Status	Technology Readiness Level	Technology Risk	Certification Risk	Insertion Timeframe	FAA Certification?	Color Code
N/A	N/A	N/A	N/A	> 10	N/A	Blue
No Concept	0 - 1	High	High	< 10	No	Red
Concept	2 - 3	Med	Med	< 5		Orange
Developing	4 - 7	Low	Low	< 2		Yellow
Operational	8 - 9	Mature	Mature	0	Yes	Green

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HUMS R&D Requirements

Primary HUMS needs by benefit, functionality, and sub-system

	Benefits			Functionality							SubSystem					
	Safety	Availability / Readiness	Cost Savings	Airborne / Ground	In-Flight Advisories	Helicopter Operational Montioring	Advanced Usage Monitoring	Health / Diagnostics	UBM / CBM	Advanced Lifing Methods	Engine	Drive	Rotor	Airframe	Electrical/ Avionics	Thermal Management
Current Capability	Med	Med	Low	A	N/A	Low	N/A	Low	N/A	N/A	Med	Med	Low	N/A	High	N/A
Future Need	High	High	High	A / G	Med to High	High	High	Med to High	Med to High	Med to High	High	High	High	Low	High	Low

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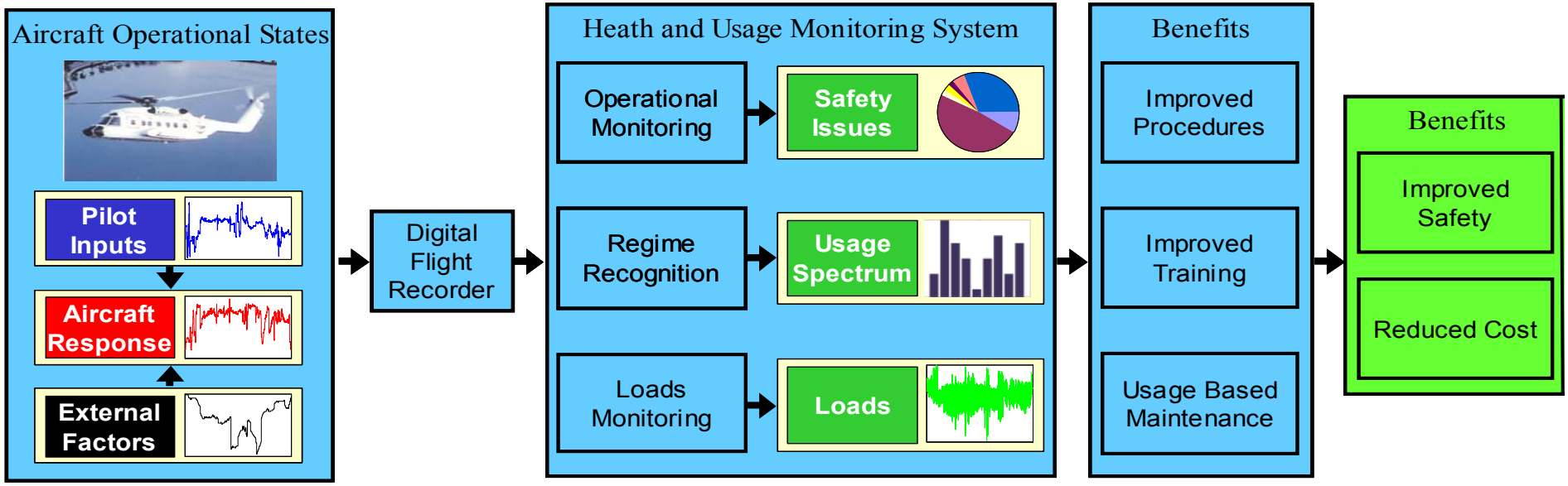
HUMS R&D Requirements

Priority 5-Year Goal: advanced usage monitoring



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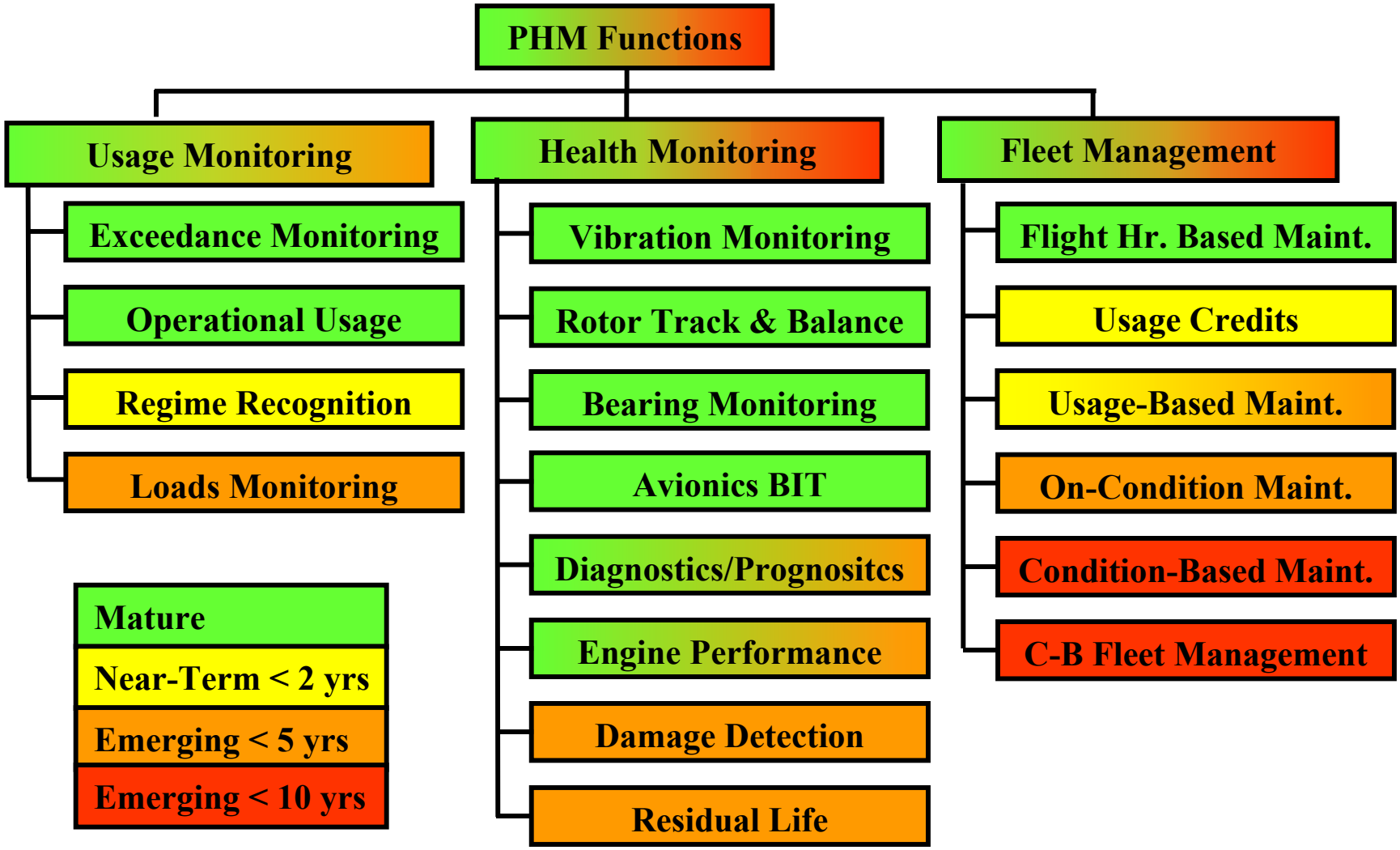
HUMS R&D Requirements

Next-generation functionality and projected time-frame



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PHM 10-Year Goal: Total aircraft condition based fleet management

Enhance Mission Reliability
Reduce Maintenance Manpower and Logistics Footprint
Catch Potentially Catastrophic Failures Before They Occur

S-61

S-76

S-92

UH-60M

VXX

CH-53E

- **Bearing Monitoring**
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- **HUMS**
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+

- **Automated Onboard Fault Detection/Isolation**
- **Portable Maintenance Aid**
- **Off-board Simulation & Diagnostics**

1998 → **2003** → **2008**

Yesterday
Safety

→

Today
Maintenance Credits

→

Tomorrow
Usage Based Maintenance

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HUMS R&D Roadmap Development

Priority 5-Yr Tasks: COTS ground station and usage-based maintenance

Task	Main R&D Tasks	Sub Tasks	Five-Year Plan and ROM ($K)					Ten-Year Plan and ROM ($K)				
			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	Continued Airworthiness of On-Board HUMS System											
2	Certification of COTS HUMS Grnd Station											
3	Validation and Certification of UBM Technologies & System											
3A		Validation of regime recognition										
3B		Certification of fleet usage credit										
3C		Certification of UBM System										
3D		Validation of loads monitoring system										
3E		Certification of component structural usage lifing & credits										

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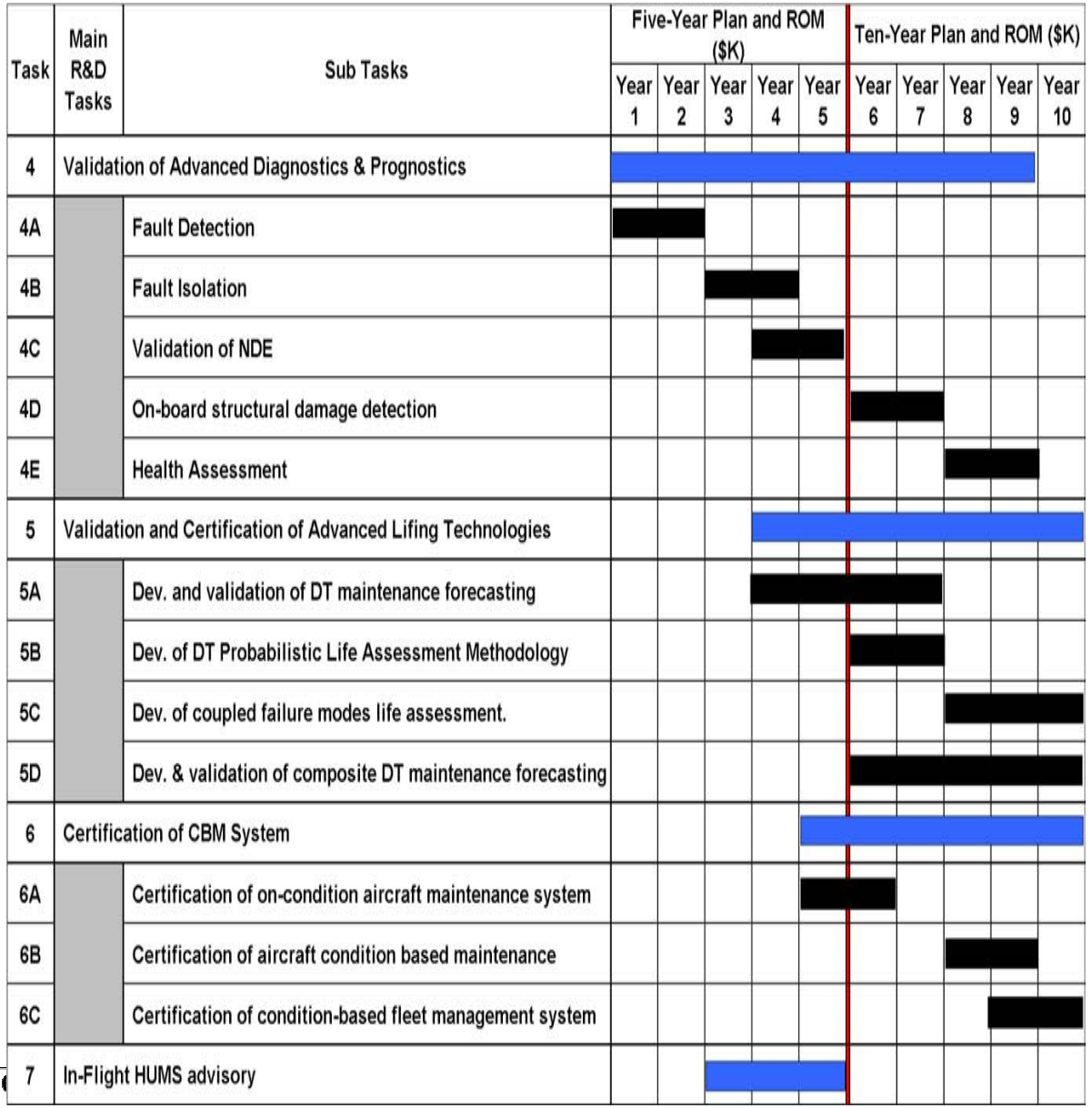
HUMS R&D Roadmap Development

Priority 10-Yr Tasks: Condition-based fleet management & enabling technologies



Task	Main R&D Tasks	Sub Tasks	Five-Year Plan and ROM ($K)					Ten-Year Plan and ROM ($K)				
			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
4	Validation of Advanced Diagnostics & Prognostics											
4A		Fault Detection										
4B		Fault Isolation										
4C		Validation of NDE										
4D		On-board structural damage detection										
4E		Health Assessment										
5	Validation and Certification of Advanced Lifing Technologies											
5A		Dev. and validation of DT maintenance forecasting										
5B		Dev. of DT Probabilistic Life Assessment Methodology										
5C		Dev. of coupled failure modes life assessment.										
5D		Dev. & validation of composite DT maintenance forecasting										
6	Certification of CBM System											
6A		Certification of on-condition aircraft maintenance system										
6B		Certification of aircraft condition based maintenance										
6C		Certification of condition-based fleet management system										
7	In-Flight HUMS advisory											

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